Introduction to Geometric Nonlinear Control Theory and Applications

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Abstract of the course

The aim of the mini-course is two-folds. In the first part we will introduce basic notions, tools, and results of geometric control theory. We will discuss the concepts of controllability, observability, decoupling, and equivalence in the context of nonlinear control systems. We will recall and/or introduce geometric tools on which the theory is based (Lie brackets, distributions and co-distributions, integral manifolds, Frobenius theorem etc.).

In the second part, we will present more recent results concerning equivalence of control systems under state- space equivalence, feedback equivalence, and dynamic equivalence.

In particular, we will discuss feedback linearization, equivalence of control-linear systems to the chained forms (and their applications to nonholonomic systems), flatness, and describe control systems that admit a mechanical structure.

Throughout the mini-course we will emphasize the geometric character of the nonlinear control theory and its applications to various control synthesis problems (stabilization, tracking, nonlinear observers). We will illustrate the course by physical, mainly mechanical, examples.

Topics

1. Geometric tools of nonlinear control (Lie bracket, distributions, Frobenius theorem).
2. Nonlinear controllability (Lie rank, orbit theorem, Chow-Rashevsky theorem, accessibility).
3. Nonlinear observability (Krener-Hermann theorem, observable/nonobservable decomposition)
4. Controlled invariant distributions, nonlinear decoupling, and zero dynamics
5. State-space, feedback and dynamic equivalence of control systems. State-space and feedback linearization.
6. Nonholonomic systems and control-linear systems equivalent to the chained forms
7. Flatness and flat control systems.
8. Mechanical control systems.